Journal of Athletic Training 2003;38(3):238–244

www.journalofathletictraining.org

Sex Differences and the Incidence of Concussions Among Collegiate Athletes

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Objective: To compare sex differences regarding the incidence of concussions among collegiate athletes during the 1997–1998, 1998–1999, and 1999–2000 seasons.

Design and Setting: A cohort study of collegiate athletes using the National Collegiate Athletic Association (NCAA) Injury Surveillance System; certified athletic trainers recorded data during the 1997–2000 academic years.

Subjects: Collegiate athletes participating in men's and women's soccer, lacrosse, basketball, softball, baseball, and gymnastics.

Measurements: Certified athletic trainers from participating NCAA institutions recorded weekly injury and athlete-exposure data from the first day of preseason practice to the final postseason game. Injury rates and incidence density ratios were computed. Incidence density ratio is an estimate of the relative risk based on injury rates per 1000 athlete-exposures.

Results: Of 14 591 reported injuries, 5.9% were classified as concussions. During the 3-year study, female athletes sustained 167 (3.6%) concussions during practices and 304 (9.5%) concussions during games, compared with male athletes, who sustained 148 (5.2%) concussions during practices and 254 (6.4%) concussions during games. Chi-square analysis revealed significant differences between male and female soccer players ($\chi^2_1 = 12.99$, $P = .05$) and basketball players ($\chi^2_1 = 5.14$, $P = .05$).

Conclusions: Female athletes sustained a higher percentage of concussions during games than male athletes. Of all the sports, women's soccer and men's lacrosse were found to have the highest injury rate of concussions. Incidence density ratio was greatest for male and female soccer players.

Key Words: mild traumatic brain injury, concussion rates, athletic injury

In recent years, interest in concussion signs and symptoms, evaluation, and long-term sequelae has increased. However, in order to prevent concussions, we need to identify at-risk groups. While many concussions are considered minor, the cumulative effects of repeated concussions can have long-term consequences.[1,2] Furthermore, certified athletic trainers and sports medicine physicians have difficulty detecting and classifying sport-related concussions because of the wide variety of signs and symptoms, and athletes may try to minimize their symptoms in order to continue participation.[3,4] Moreover, Barnes et al[5] and Boden et al[6] suggested that concussions are more common in some collegiate sports than previously anticipated. Powell and Barber-Foss[7] concluded that 3.9% of all injuries in all sports were mild traumatic brain injuries (MTBIs) and that approximately 40 000 per 1.1 million high school football players sustained concussions each year. Consequently, we need to identify which group of athletes is at risk and address methods for preventing concussions.

The Quality Standards Subcommittee of the American Academy of Neurology[8] described cerebral concussions as an altered mental state that may or may not include loss of consciousness. This subcommittee agreed that the most prominent symptoms of concussions are amnesia and confusion.[8]

Most of the literature regarding concussions concentrates on football and ice hockey players. Few studies to date have compared collegiate sports or identified which athletes are more at risk for suffering concussions.[6] Very few studies have compared sex differences among collegiate athletes who sustain a concussion.[5,7] However, female collegiate sports teams, especially in soccer and lacrosse, have expanded immensely across the nation. It can be argued that male athletes may be at greater risk for concussions due to their aggressive nature or the faster pace of the sport, or both, while female athletes may be at greater risk due to their smaller size and weaker neck strength.[5] This information is critical to helping the National Collegiate Athletic Association (NCAA) Committee on Competitive Safeguards and Medical Aspects of Sports recognize if there is a need to modify rules or equipment to help reduce the number of concussions sustained by collegiate athletes. Hence, it is important to determine if male or female athletes may be at a more inherent risk of sustaining a concussion in collegiate sports.

Similar studies have been conducted at the high school level by Powell and Barber-Foss,[7] who examined MTBIs in 10 male and female high school sports. They described MTBI as a traumatic brain or head injury resulting in an athlete's removal from participation. The rate of MTBI was slightly higher in girl's soccer (6.2%) than in boy's soccer (5.7%), in girl's basketball (5.2%) than in boy's basketball (4.2%), and in softball (2.1%) than in baseball (1.2%).

Soccer is one of the only sports in which researchers have compared sex differences at the collegiate level with regard to

concussions and neurologic or neuropsychological impairments.[5–7] In 1998, Barnes et al[5] and Boden et al[6] concluded that men had a higher incidence of concussions than women and that concussions were becoming more common than previously anticipated.

Our purpose was to compare sex differences in the incidence of concussions among collegiate athletes in men's and women's soccer, lacrosse, basketball, softball/baseball, and gymnastics during the 1997–1998, 1998–1999, and 1999–2000 seasons.

METHODS

Data were collected using the NCAA Injury Surveillance System (ISS). The ISS includes 15 sports: 5 fall sports (field hockey, football, men's soccer, women's soccer, and women's volleyball), 6 winter sports (men's basketball, women's basketball, men's gymnastics, women's gymnastics, men's ice hockey, and men's wrestling), and 5 spring sports (baseball, men's lacrosse, women's lacrosse, spring football, and softball). Data collected from each sports season (fall, winter, spring) are then summarized and reviewed by the NCAA Committee on Competitive Safeguards and Medical Aspects of Sports. The current study involved an analysis of tabular data provided and authorized for use by the NCAA.

The ISS defines a reportable injury as one that "occurs as a result of participation in an organized collegiate practice or game, requires medical attention by a team athletic trainer or physician, and results in restriction of the student-athlete's participation for one or more days beyond the day of injury."[9] Certified athletic trainers from participating NCAA institutions record weekly injury and exposure data from the first day of preseason practice to the final postseason game.

Sampling

Participation in the NCAA ISS system is voluntary. Participants represent at least 10% of each region (East, South, Midwest, and West) and NCAA Division (I, II, and III).[14] For the 10 sports studied during the fall 1997 to spring 2000 academic years, the ISS documented 2263 team-seasons, 14 591 (7413 practice + 7178 games = 14 591) reportable injuries, 2 465 565 practice athlete-exposures, and 726 436 game athlete-exposures.

Exposures

An athlete-exposure (AE) is defined by the ISS as an athlete participating in one practice or game in which he or she is exposed to the possibility of athletic injury.[9] Certified athletic trainers summarized the number of practice exposures (PEs) and game exposures (GEs). For example, 4 practices, each involving 15 participants, and 2 games involving 9 participants, would result in 60 PEs, 18 GEs, and 78 overall AEs for that week.

Definition of Concussion

The NCAA Injury Surveillance System describes a cerebral concussion based on the following grading scale.[10] This grading scale was consistent throughout the 3-year study.[10]

- Grade 1: No loss of consciousness, short duration of posttraumatic amnesia
- Grade 2: Loss of consciousness (less than 5 minutes), amnesia up to 30 minutes
- Grade 3: Loss of consciousness (more than 5 minutes), extended amnesia

Injury Rate

The ISS defines an injury rate as the ratio of the number of injuries in a specific sport to the number of AEs in the same sport, multiplied by a reference population of 1000 AEs.[9] The categorical variables are sex and sport. The dependent variables are injury rate and incidence density ratio.

Statistical Analysis

Incidence density ratio (IDR) is an estimate of the relative risk of injury.[7] Incidence density ratio compares game injury rates to practice injury rates of athletes sustaining an injury.[7] It is calculated by dividing the injury rate of games by the injury rate of practice sessions.[7] This IDR describes the relative risk of injury for games compared with practices within the same sport.

Because sex and sport are classified as nominal scales, we chose a nonparametric test to analyze the data.[11] A χ^2 test was used to determine if the 2 populations (men's soccer versus women's soccer) were different on a dependent variable (concussion incidence).[11] A significant χ^2 finding indicates that the 2 populations are not homogeneous.[11] Because of unequal numbers of AEs, we calculated iteration proportion-fitting χ^2 tests to create theoretic expected values.[11] For example, when comparing male and female soccer players, the observed value was the total number of concussions reported during the 3 years (women = 158, men = 101, total = 259). In order to determine the expected value, we first summed the AEs for the 3 years (women = 75 082, men = 75 745, total = 150 827), calculated the percentage of female and male AEs (women, 75 082/150 827 = 49.8%; men, 75 745/150 827 = 50.2%), and then created the theoretic expected value (women, 259 × 0.498 = 129.0; men, 259 × 0.502 = 130.0). The 95% confidence intervals were calculated according to the methods of Miettinen.[11]

The injury percentages among the different sports focused on the proportion of the reported concussions to all injuries reported during each individual game or practice session. The statistical significance level was set at $P < .05$ for sex and at $P < .001$ for sport, following the guidelines of the Bonferroni correction.[11] We proposed 3 hypotheses. First, concussion incidence rates among sports would not differ by sex. Second, female collegiate athletes would not exhibit differences in concussions among the 5 female sports. Third, male collegiate athletes would not exhibit differences in concussions among the 5 male sports.

RESULTS

Of the total reported injuries, male and female athletes sustained 315 (315/7413 = 4.2%) concussions during practices and 558 (558/7178 = 7.8%) concussions during games (Table 1). Of the total reported injuries, female athletes sustained 167 (3.6%) concussions during practices and 304 (9.5%) concussions during games (Table 2). Male athletes sustained 148 (5.2%) concussions during practices and 254 (6.4%) concussions during games.

Table 1. Total Game Concussions and Concussion Rates by Sport, Year, and Sex

		Women			Men			
Sport	Year	Game Exposures	Total Concussions	Game Injury Rates*	Game Exposures	Total Concussions	Game Injury Rates*	χ^2 Value Between Sexes
Soccer	1997–1998	24 981	51	2.04	30 966	34	1.10	12.99†
	1998–1999	22 934	47	2.04	19 142	27	1.41	
	1999–2000	27 167	60	2.21	25 636	40	1.56	
Lacrosse	1997–1998	8762	12	1.37	13 486	19	1.41	1.63
	1998–1999	7122	7	0.98	9514	15	1.58	
	1999–2000	8531	7	0.82	12 177	17	1.39	
Basketball	1997–1998	29 413	16	0.54	27 706	8	0.29	5.14†
	1998–1999	38 174	30	0.78	39 367	21	0.53	
	1999–2000	28 992	26	0.89	32 836	20	0.61	
Softball/ baseball	1997–1998	26 834	9	0.34	51 351	22	0.43	0.99
	1998–1999	44 280	10	0.23	49 207	6	0.12	
	1999–2000	75 355	28	0.37	80 215	25	0.31	
Gymnastics	1997–1998	8903	1	0.11	227	0	0	0.14
	1998–1999	822	0	0	221	0	0	
	1999–2000	2083	0	0	1179	0	0	
Total		354 353	304		393 230	254		

*Injury rates are based on 1000 game exposures.
†Statistically significant.

Concussions within Male Sports

Male soccer players sustained a significantly greater number of concussions than male basketball players ($\chi^2_1 = 21.25$, $P \leq .05$) and baseball players ($\chi^2_1 = 96.56$, $P \leq .05$) (Table 3). Male lacrosse players experienced concussions significantly more often than male basketball players ($\chi^2_1 = 32.47$, $P \leq .05$) and baseball players ($\chi^2_1 = 82.19$, $P \leq .05$). No other significant differences were reported among the 5 male sports.

Male lacrosse players were at a 5.8 times greater risk of suffering a concussion during a game situation than male baseball players (Table 4). The IDRs for male soccer players were 5.4 and 3.2 during game situations when compared with male baseball and basketball players, respectively. Male lacrosse players were more than 3 times as likely to sustain a concussion during a game when compared with male basketball players (IDR = 3.4). Male soccer and male lacrosse players had an equal risk of sustaining a concussion during a game (IDR = 1.1).

Concussions Within Female Sports

Female soccer players had a significantly greater number of concussions than female lacrosse players ($\chi^2_1 = 10.7$, $P \leq .05$), basketball players ($\chi^2_1 = 58.38$, $P \leq .05$), softball players ($\chi^2_1 = 170.49$, $P \leq .05$) and gymnasts ($\chi^2_1 = 20.33$, $P \leq .05$). Female lacrosse players experienced concussions significantly more often than softball players ($\chi^2_1 = 27.27$, $P \leq .05$) and gymnasts ($\chi^2_1 = 10.25$, $P \leq .05$). Female basketball players experienced concussions significantly more often than gymnasts ($\chi^2_1 = 105.9$, $P \leq .05$) and softball players ($\chi^2_1 = 101.04$, $P \leq .05$). No other significant differences were reported among the 5 female sports.

The IDRs for female soccer and lacrosse players were 58.2 and 29.3, respectively, during game situations when compared with female gymnasts (Table 5). Female basketball players were at an 18.7 times greater risk for suffering a concussion during a game situation when compared with female gymnasts. Female soccer players were at a 7 times greater risk of suffering a concussion than female softball players. Female soccer players were 2 times more likely to sustain a concussion than female lacrosse players during a game (IDR = 2.0).

Soccer

Female soccer players sustained significantly more concussions than male soccer players ($\chi^2_1 = 12.99$, $P \leq .05$). In men's soccer, 267 teams were analyzed. A total of 123 concussions occurred, accounting for 7.0% of all male soccer game injuries and 1.7% of all male practice injuries. Male soccer players were at a 17.7 times greater risk of suffering a concussion during games than practices. Data were collected for 288 women's soccer teams, with 192 concussions reported. Of all the injuries reported, female game concussions accounted for 11.4% and female practice concussions accounted for 2.4%. The IDR was 16.7 times higher for games than practice sessions.

Lacrosse

Data were available on 119 men's lacrosse teams, and 80 concussions occurred. Of all injuries sustained during men's lacrosse, 10.1% represented game concussions and 4.0% represented practice concussions. The IDR for men's lacrosse was 11.2. In women's lacrosse, 112 teams provided data, and 48 concussions were sustained. Of all injuries sustained during women's lacrosse, 5.3% represented practice concussions and 13.9% represented game concussions. The IDR was 4.8 times higher during games than practices. Chi-square analysis for male and female lacrosse players was not significant ($\chi^2_1 = 1.63$, $P > .05$).

Basketball

Female basketball players sustained 147 concussions, while male basketball players suffered 118 concussions ($\chi^2_1 = 5.14$,

Table 2. Concussion Frequency and Rate by Sport, Year, and Setting for Women

Sport	Year	Practice Exposures	Total Concussions	Practice Injury Rates*	Game Exposures	Total Concussions	Game Injury Rates†	Incidence Density Ratio
Soccer	1997–1998	87 442	12	0.14	24 981	51	2.04	16.7
	1998–1999	77 286	9	0.11	22 934	47	2.04	
	1999–2000	100 855	13	0.13	27 167	60	2.21	
95% Confidence interval				0.09–0.16			2.29–1.9	
Lacrosse	1997–1998	33 342	14	0.42	8762	12	1.37	4.8
	1998–1999	31 048	3	0.1	7122	7	0.98	
	1999–2000	37 765	5	0.14	8531	7	0.82	
95% Confidence interval				−0.12–0.56			1.61–0.50	
Basketball	1997–1998	104 872	24	0.23	29 413	16	0.54	3.4
	1998–1999	140 817	26	0.19	38 174	30	0.78	
	1999–2000	108 480	25	0.23	28 992	26	0.89	
95% Confidence interval				0.17–0.26			0.91–0.44	
Softball	1997–1998	45 291	7	0.15	26 834	9	0.34	2.5
	1998–1999	76 076	7	0.09	44 280	10	0.23	
	1999–2000	129 155	17	0.14	75 355	28	0.37	
95% Confidence interval				0.06–0.19			0.42–0.18	
Gymnastics	1997–1998	31 006	4	0.13	8903	1	0.11	2.0
	1998–1999	9253	0	0	822	0	0	
	1999–2000	19 829	1	0.05	2083	0	0	
95% Confidence interval				−0.07–0.19			−0.08–0.16	
Total		1 032 517	167		354 353	304		

*Injury rates are based on 1000 practice exposures.
†Injury rates are based on 1000 game exposures.

Table 3. Concussion Frequency and Rate by Sport, Year, and Setting for Men

Sport	Year	Practice Exposures	Total Concussions	Practice Injury Rates*	Game Exposures	Total Concussions	Game Injury Rates†	Incidence Density Ratio
Soccer	1997–1998	127 013	10	0.08	30 966	34	1.10	17.7
	1998–1999	77 769	8	0.11	19 142	27	1.41	
	1999–2000	106 241	4	0.04	25 636	40	1.56	
95% Confidence interval				0.01–0.15			0.89–1.81	
Lacrosse	1997–1998	76 246	11	0.14	13 486	19	1.41	11.2
	1998–1999	56 201	4	0.07	9514	15	1.58	
	1999–2000	74 115	14	0.19	12 177	17	1.39	
95% Confidence interval				0.02–0.25			1.26–1.66	
Basketball	1997–1998	118 905	16	0.14	27 706	8	0.29	2.9
	1998–1999	164 607	31	0.19	39 367	21	0.53	
	1999–2000	140 637	22	0.16	32 836	20	0.61	
95% Confidence interval				0.11–0.21			0.17–0.69	
Baseball	1997–1998	129 623	10	0.08	51 351	22	0.43	4.5
	1998–1999	130 988	9	0.07	49 207	6	0.12	
	1999–2000	213 674	9	0.04	80 215	25	0.31	
95% Confidence interval				−0.34–0.47			−0.04–0.54	
Gymnastics	1997–1998	3897	0	0	227	0	0	0.0
	1998–1999	3265	0	0	221	0	0	
	1999–2000	9867	0	0	1179	0	0	
95% Confidence interval				0–0			0–0	
Total		1 433 048	148		393 230	254		

*Injury rates are based on 1000 practice exposures.
†Injury rates are based on 1000 game exposures.

Table 4. Game Incidence Density Ratio for Men's Sports

Sport (Average 3-Year Game Injury Rate)		Incidence Density Ratio
Lacrosse (1.460)	Baseball (0.250)	5.8
Soccer (1.358)	Baseball (0.250)	5.4
Lacrosse (1.460)	Basketball (0.430)	3.4
Soccer (1.358)	Basketball (0.430)	3.2
Basketball (0.430)	Baseball (0.250)	1.7
Lacrosse (1.460)	Soccer (1.358)	1.1
Soccer (1.358)	Gymnastics (0)	0
Lacrosse (1.460)	Gymnastics (0)	0
Baseball (0.250)	Gymnastics (0)	0
Basketball (0.430)	Gymnastics (0)	0

Table 5. Game Incidence Density Ratios for Women's Sports

Sport (Average 3-Year Game Injury Rate)		Incidence Density Ratio
Soccer (2.096)	Gymnastics (0.036)	58.2
Lacrosse (1.056)	Gymnastics (0.036)	29.3
Basketball (0.676)	Gymnastics (0.036)	18.7
Softball (0.300)	Gymnastics (0.036)	8.3
Soccer (2.096)	Softball (0.300)	7.0
Lacrosse (1.056)	Softball (0.300)	3.5
Soccer (2.096)	Basketball (0.676)	3.1
Basketball (0.676)	Softball (0.300)	2.3
Soccer (2.096)	Lacrosse (1.056)	2.0
Lacrosse (1.056)	Basketball (0.676)	1.6

$P \leq .05$). Athletic trainers reported on 376 female basketball teams, with an IDR 3.4 times greater for games than practices. Concussions in women accounted for 4.7% of all the total injuries sustained during female basketball practices and 8.5% during female basketball games. In men's basketball, 372 teams were analyzed, with an IDR of 2.9. Concussions in male basketball players accounted for 4.1% of all the total injuries sustained during male basketball practices and 5.0% during male basketball games.

Softball/Baseball

We received data on 337 baseball teams, including 81 concussions. The IDR was 4.5 times higher during games than during practices. Concussions accounted for 2.9% of all baseball practice injuries and 4.2% of all baseball game injuries. No significant differences were noted between baseball and softball players ($\chi^2_1 = 0.19$, $P > .05$). Data were collected in the sport of softball for 331 teams, including 78 concussions. The IDR was 2.5 times greater for softball games than for practice sessions. Softball practice concussions accounted for 4.1% of all injuries and game concussions accounted for 6.4% of all injuries.

DISCUSSION

Our purpose was to compare sex differences regarding the incidence of concussions among collegiate sports during the 1997–1998, 1998–1999, and 1999–2000 seasons. During this time, concussions accounted for 5.9% of all reported collegiate injuries, whereas Powell and Barber-Foss[7] noted that 3.9% of all injuries suffered in high school sports were MTBIs. The discrepancy may be attributed to differences in our sample population size or sample and the design of the study. We examined concussions sustained by collegiate athletes, while Powell and Barber-Foss[7] explored MTBIs among high school athletes. Collegiate sports are played at a faster pace, and the athletes are bigger or stronger (or both) and more aggressive in competitive play, which may contribute to the higher percentage of concussions.

Sports at Highest Risk for Concussion

Collegiate-sport team athletes at highest risk for suffering a concussion were male and female lacrosse, male and female soccer, and female basketball players. A possible explanation may be attributed to the nature of each sport. For example, soccer does not involve intentional collisions between players; however, incidental collisions occur frequently.[6] In addition, soccer players are often required to "head" the ball, but occasionally they miss the ball and strike their opponent's head. Although male lacrosse players are required to wear helmets, the higher incidence of concussions may be the result of their style of play. For example, male lacrosse players are permitted to make body contact with their opponents, which may result in a concussion. Female collegiate lacrosse players are not required to wear a helmet because the sport is classified as noncontact.[9] However, unintentional collisions with opponents' heads or sticks may contribute to the high incidence of concussions.[12]

Sports at Lowest Risk for Concussion

Athletes who participate in men's and women's gymnastics, baseball, and softball are at the lowest risk for suffering a concussion. No other published studies have identified or quantified the relative risk of concussion in these NCAA collegiate sports. Again, a possible explanation may be attributed to the nature and safety aspects of each sport. All the sports are considered noncontact/noncollision sports. Gymnastics is considered a high-risk sport for all injuries; however, our data revealed a low number of concussions. Gymnastics is also an individual sport; therefore, athletes are not at risk of being hit by an opponent, although concussions may occur if they strike their heads on the floor, balance beam, bars, or vault. However, the use of protective equipment and apparatuses may minimize the forces transmitted to the head. Baseball and softball players wear a helmet to protect them from head injuries. The administrators of these sports have identified and acknowledged the risk of concussion and established rules to encourage the use of protective equipment such as helmets.

Female Athletes and Concussions

Female soccer players experienced concussions significantly more often than female basketball, lacrosse, and softball players and gymnasts. While women's soccer had the highest rate of concussions, women's lacrosse had the highest inherent risk of sustaining a concussion during a game situation. Recently, coaches and safety committees have been debating whether lacrosse and soccer players should wear safety equipment to protect them from facial and head injuries.[12,13] Coaches suggest that if safety equipment is worn by female lacrosse players, the athletes will become more aggressive, making the game more dangerous.[12] During the start of the 1999 season, women's lacrosse implemented the restraining-line rule, which limits the number of players inside the critical scoring area.

This rule may have led to the decreased injury rates for concussions, dropping from 1.29 during the 1998 season to 0.98 and 0.82 during the 1999 and 2000 seasons, respectively.

Sex Differences and Concussions

Female basketball players were more likely to sustain concussions than male basketball players, a finding consistent with Powell and Barber-Foss,[7] who also reported a greater incidence of concussions in female basketball players compared with male players. However, we noted slightly higher injury rates for both female and male collegiate basketball players compared with athletes in other sports. One possible reason for the differences between our study and that of Powell and Barber-Foss[7] is that we examined collegiate athletes, who may be bigger, stronger, and more aggressive than high school players. Although basketball is considered a contact sport, the use of elbows is becoming more prevalent, possibly leading to more concussions.[14] Starkey[14] described basketball as evolving from a finesse sport to a high-risk contact sport. Consistent with this trend, Starkey[14] found that game injury rates were twice as high for National Basketball Association players as for NCAA basketball players.

Female soccer players had the highest number and injury rate of concussions, and they suffered concussions significantly more often during soccer games than did male soccer players. This finding is consistent with Powell and Barber-Foss,[7] who reported that women are at greater risk than men for sustaining an MTBI. Different populations may explain the differences in our data and those of Barnes et al[5] and Boden et al,[6] who concluded that male soccer players were at greater risk of suffering a concussion than female soccer players. Our results may be attributed to such factors as the sample population or the design of the study. Barnes et al[5] studied 144 elite female and male soccer players competing at the 1993 United States Olympic Festival. Athletes were asked to recall their history of concussions, symptoms experienced heading the ball, and the mechanism involved when suffering a concussion. As a result, recall bias may have played a factor in the findings.[5] Boden et al[6] examined concussion incidence in soccer players participating only in the Atlantic Coast Conference (ACC). The ACC is considered a highly competitive conference in men's soccer, which may be a contributing factor in the higher rates of concussions.[6] The competitive nature of the ACC for men's soccer compared with the cross-sectional sample used by the NCAA may account for the results.[6] Our sample is not as homogeneous due to the inclusion of Division I, II, and III athletes.

A number of possible reasons may explain why female soccer players sustained a significantly greater number of concussions than male soccer players. First, female athletes could be at more risk due to their smaller size or greater ball-to-head size ratio.[5] Second, female athletes may have weaker neck muscles than male athletes.[5] Third, Barnes et al[5] suggested that, anecdotally, women soccer players head the ball more than male soccer players do. Finally, Boden et al[6] suggested that men may be more skilled at protecting their heads from injury, but there are no data to support this hypothesis.

Limitations

Our study had several limitations. First, there is no single definition of concussion used by the NCAA ISS. As a result, variations in data may reflect variations in the interpretations of the recorders for concussion between the sexes and among the sports. However, all subjects had to have missed at least 1 day due to injury. Thus, the sports medicine profession needs to agree upon a consistent definition of concussion and a grading scale.

Another limitation to this study is the evaluation of AEs. The ISS defines AE as an athlete participating in 1 practice or game in which he or she is exposed to the possibility of athletic injury. As a result, time played is not considered in the definition of AE.

CONCLUSIONS

Concussions accounted for 5.9% of all reported injuries during this 3-year study. Female soccer players experienced concussions significantly more often than female basketball, lacrosse, and softball players and gymnasts. Female basketball and lacrosse players suffered a significantly greater number of concussions when compared with female softball players and gymnasts. Male soccer and lacrosse players sustained significantly more concussions when compared with male basketball and baseball players. Female athletes were found to be at a greater risk for suffering a concussion during games than male athletes. Female soccer and basketball players suffered concussions significantly more often than male soccer and basketball players, respectively. We provide the first analysis of at-risk groups, sex and sport differences, and practice and game incidences for concussions sustained by collegiate athletes. With this information, coaches, athletic trainers, and administrators may be able to explore injury-prevention strategies and further research individual risk factors responsible for sex, sport, game, and practice differences in the incidence of concussions.

ACKNOWLEDGMENTS

We thank Randy Dick, MS, Research Program Director for the NATA Injury Surveillance System, for his assistance in obtaining and interpreting the data.

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